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Enhancing ICT Skills Among Pre-Service Teachers in Australia: Legal, Ethical, and Educational Perspectives on Digital Competence

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Abstract: The rapid digital transformation of education has significantly increased the demand for strong Information and Communication Technology (ICT) competencies among pre-service teachers in Australia. Beyond technical proficiency, future educators are increasingly expected to understand the legal, ethical, and pedagogical implications associated with the use of digital technologies in educational environments. This study investigates the development of digital competence among Australian pre-service teachers from integrated legal, ethical, and educational perspectives. Using a mixed-methods approach, the study examines pre-service teachers' perceptions of ICT readiness, institutional training strategies, and the challenges encountered in technology-enhanced learning environments. Particular attention is given to issues related to data privacy, cybersecurity awareness, intellectual property protection, artificial intelligence ethics, and responsible digital citizenship within teacher education programs. The research further analyzes how current educational policies and regulatory frameworks influence ICT training effectiveness and professional preparedness. The findings indicate that although pre-service teachers generally demonstrate positive attitudes toward ICT integration, substantial gaps remain in legal literacy, ethical decision-making, and practical digital governance awareness. Limited hands-on training, unequal access to digital resources, and insufficient interdisciplinary instruction were identified as major barriers to effective ICT competency development. The study highlights the importance of incorporating legal and ethical education into teacher preparation curricula to strengthen responsible technology use and sustainable digital pedagogy. This research contributes to ongoing discussions on digital education reform by proposing a comprehensive framework that integrates technological skills, legal compliance, and ethical awareness into pre-service teacher education. The study offers practical implications for policymakers, universities, and teacher training institutions seeking to enhance digital competence and professional readiness in contemporary educational contexts.

Keywords: Information and Communication Technology (ICT); Pre-Service Teachers; Digital Competence; Educational Technology; Educational Technology; Legal and Ethical Issues

1 Introduction

The rapid advancement of digital technologies has fundamentally transformed contemporary educational systems worldwide, reshaping teaching methodologies, learning environments, and institutional governance. In Australia, the increasing integration of Information and Communication Technology (ICT) into primary, secondary, and higher education has intensified expectations for teachers to possess not only technical proficiency but also broader digital competence that encompasses ethical judgment, legal literacy, and responsible pedagogical practice (Australian Institute for Teaching and School Leadership [AITSL], 2022). As educational institutions continue to adopt online learning platforms, artificial intelligence (AI) tools, cloud-based collaboration systems, and digital assessment technologies, pre-service teachers are expected to demonstrate the ability to navigate complex digital ecosystems while ensuring compliance with legal and ethical standards.

Digital competence has emerged as a multidimensional concept that extends beyond basic operational ICT skills. Contemporary frameworks define digital competence as the integration of technological knowledge, critical thinking, communication abilities, cybersecurity awareness, and ethical responsibility in digital environments (Redecker, 2017). Within teacher education, digital competence is increasingly associated with teachers' capacity to effectively integrate technology into classroom instruction while promoting safe, inclusive, and legally compliant learning experiences (Tondeur et al., 2017). Australian educational reforms have similarly emphasized the importance of preparing future educators who can respond to the demands of technology-enhanced learning and digital transformation initiatives across schools and universities (Department of Education, Skills and Employment [DESE], 2021).

Despite significant investments in educational technologies, numerous studies have identified persistent challenges in ICT competency development among pre-service teachers. While many teacher education programs provide foundational technological training, insufficient attention has often been devoted to the legal and ethical dimensions of digital teaching practices (Instefjord & Munthe, 2017). Issues such as data privacy protection, intellectual property rights, cyberbullying prevention, algorithmic bias, AI ethics, and responsible digital citizenship have become increasingly relevant in educational settings where digital technologies mediate communication, assessment, and knowledge production (Selwyn, 2016). The growing use of AI-driven educational tools further raises concerns regarding transparency, accountability, surveillance, and the ethical use of student data in schools and universities (Williamson & Eynon, 2020).

In the Australian context, legal and regulatory frameworks governing digital education continue to evolve alongside technological innovation. Policies associated with privacy legislation, copyright law, online safety regulations, and cybersecurity standards increasingly influence how educational institutions design ICT training programs and manage digital learning environments (Office of the Australian Information Commissioner [OAIC], 2023). Pre-service teachers are therefore expected to understand not only how to use digital technologies effectively but also how to comply with professional responsibilities related to student data protection, digital content usage, and ethical online conduct. However, previous research suggests that many teacher education programs still prioritize technical skills over critical digital governance competencies, resulting in gaps between technological adoption and responsible professional practice (Kimmons & Hall, 2018).

Furthermore, disparities in access to digital resources and institutional support continue to affect ICT readiness among pre-service teachers. Differences in technological infrastructure, socioeconomic background, and institutional capacity may contribute to unequal opportunities for developing advanced digital competencies (Howard et al., 2021). Limited hands-on experiences with authentic educational technologies and insufficient interdisciplinary instruction may also hinder pre-service teachers' confidence and preparedness in applying ICT within real classroom contexts. Consequently, there is a growing need for comprehensive teacher preparation models that integrate technological, pedagogical, legal, and ethical perspectives into ICT education.

This study investigates the development of ICT competence among Australian pre-service teachers through an integrated legal, ethical, and educational lens. Using a mixed-methods approach, the research explores pre-service teachers' perceptions of ICT readiness, institutional training strategies, and the challenges associated with technology-enhanced learning environments. Particular attention is devoted to examining issues related to cybersecurity awareness, data privacy protection, AI ethics, intellectual property compliance, and responsible digital citizenship within teacher education programs. Additionally, the study analyzes how current educational policies and regulatory frameworks influence the effectiveness of ICT training and professional preparedness.

The significance of this research lies in its interdisciplinary perspective on digital competence development. Unlike previous studies that focus primarily on technical ICT skills, this study emphasizes the importance of integrating legal compliance and ethical awareness into teacher preparation curricula. By identifying existing gaps in digital governance knowledge and professional readiness, the study contributes to ongoing discussions concerning digital education reform and sustainable

technology integration in Australian education. The findings are expected to provide practical implications for policymakers, universities, and teacher training institutions seeking to strengthen responsible technology use and enhance the professional competence of future educators in increasingly digitalized educational environments.

2 Literature review

Theme 1. Relevance of ICT Skills and education

The Australian Curriculum describes ICT capability as the ability to use digital technologies to access, create and communicate information and ideas, and to solve problems — emphasizing purposeful, ethical and curriculum-linked use. (ACARA, 2022). And UNESCO's ICT Competency Framework for Teachers (2011) defines ICT competence as the ability to apply digital technologies effectively and ethically in teaching and learning, including pedagogical integration, professional development and support for learners. (UNESCO, 2011). Managing, evaluating, creating, and sharing information using digital tools are all examples of ICT skills that are important for people to have in the 21st century. Voogt and Roblin (2012) say that ICT skills are important for both professional and personal growth. Katz and Macklin (2007) say that ICT literacy is the skill of properly utilizing digital technology, communication tools, and networks to fetch, organize, combine, assess, and create data. This way of thinking makes it clear that teachers need to learn more than just how to use tools; they must understand how to use them in useful ways. However, Improving the level of teaching and learning with ICT is more than just knowing how to use technical tools. By using ICT to improve their teaching, Majumdar (2015) says that teachers should oversee making their own learning settings. Australian teachers-to-be think that ICT skills are essential, but they have a hard time getting ready for their jobs and being effective teachers. Gill, Dalgarno, and Carlson (2015) say, "One of the biggest challenges for teacher educators is making sure that pre-service teachers have the learning experiences at university and on professional placement that will help them develop these skills" (p. 36). Gill and Dalgarno (2008) say that one of the most significant things for educators to do is make sure that "graduate teachers have the necessary combination of skills and pedagogical knowledge that will enable them to both effectively use today's technologies in the classroom as well as continue to develop and adapt to new technologies that emerge in the future" (pp. 330–331). They also say that "the pre-service teachers' personal preparedness, which includes attitude, motivation, and confidence, as well as a number of social factors, are crucial" (p. 331). Beyond technical knowledge, these findings show that things like real experience, understanding of how to teach, and individual perceives have a big impact on how well ICT is integrated.

However, study from OECD countries shows that ICT is not always a part of Initial Teacher Education (ITE). A lot of teachers-to-be don't have the advanced ICT integration skills that are needed in modern classes (OECD, 2009–2018). According to research, most Australian pre-service teachers know how important ICT skills are for getting ready for the classroom and being more effective teachers. However, their views are complicated and full of detail. There is a lot of agreement among pre-service teachers that ICT is significant, but Albion and Ertmer (2002, p. 36) say that this agreement is usually only on the surface: "Although pre-service teachers often indicate that ICT is vital, their conceptions often lack depth and integration with pedagogical frameworks." This quick impression suggests a big difference between what is known in theory and what is understood in practice, which could make it harder to use ICT effectively in schools. Furthermore, Tondeur et al. (2017, p. 34) stress that "Australian pre-service teachers express confidence in using basic ICT tools, yet their readiness declines sharply when required to integrate advanced technologies into authentic teaching scenarios." This makes things even more complicated. Above literature results show that there is a big difference between how ready people think they are and how ready they really are. This makes a lot of wonder if pre-service teacher education programs teach students the advanced ICT integration skills they need to teach today. Furthermore, Lemon and Garvis's (2016, p. 4) study show how pre-service teachers think about things, stating that "many pre-service teachers in Australia perceive ICT skills as integral yet simultaneously express anxiety about maintaining pace with rapidly evolving technologies." This two-sided view highlights a major problem in the readiness of future teachers: they often understand the significance ICT is, but their self-perceived limits and worry make them less successful in the classroom. Collectively, these critical reviews of existing literature show that while Australian pre-service teachers think ICT skills are useful, there is still a big gap between what they think they are ready to do and what they are ready to do. This needs to be looked at more closely in teacher education programs.

Theme 2 Impacts on Students

2.1 creativity.

Australian study shows that students who are better at using computer technology (ICT) are more likely to be able to think of creative thoughts. This is especially true in learning settings with lots of technology. "Students with better developed computing skills scored higher on critical and creative thinking activities" (McMahon, 2009, p. 4) in a study done in a secondary school in Western Australia. The

study also found a good, but not straight link between how long students used digital tools and how well they did on jobs that required them to come up with creative solutions. This shows that having access to ICT does not automatically make someone creative, but learning useful digital skills can help and improve creative expression. Furthermore, The Australian Curriculum also includes ICT as a general skill, with the goal of teaching students use ICT effectively and appropriately to access, create, and communicate information and ideas in new ways (ACARA, 2022, para. 1). The fact that ICT is built into national education guidelines shows that teachers want to encourage imagination as a key skill for the 21st century, which can be strengthened through digital interaction. ICT lets students get to, expand, change, and share knowledge in a variety of forms and styles. This encourages them to think critically and creatively, solve problems, and work together (Majumdar, 2015). These skills are very important for making pupils independent and self-directed. Using technology in the classroom can help students learn a lot by encouraging them to be learner -centered and work together. A mixed-methods study was done by the NSW Centre for Education Statistics and Evaluation (CESE) on ICT can be used to teach writing to students in Years 4–6. Teachers who went to professional development used computers to write rough drafts, make plans, review, and work together on writing. The data above showed that students' writing quality, rewriting skills, and creativity all got a lot better.

2.2 positive attitudes and achievement

Long-term, well-integrated use of ICT in schools improves students' learning, confidence, and positive attitudes toward technology. Lei et al. (2021) show that there is a link between students' ICT skills and their academic success, especially at the high school level. Dix (2007) did an extended study with 2,560 students and 219 teachers in six public schools in South Australia. He found that long-term ICT integration made students feel better about themselves, gave them more confidence, and made them more open-minded to computer-based learning. Notably, the study saw changes in gender equality, with female students saying they felt better about themselves and had more confidence in ICT environments. Jamieson-Proctor et al. (2016) also looked at how LMS platforms, online tests, groups, and digital whiteboards were used in Queensland classes by using polls and classroom observations. Their research showed that schools with a lot of ICT integration had more motivated students, more personalized learning experiences, faster feedback, and more engaged students, which means that integrating ICT well can have a direct effect on how effectively students learn. Researchers in Australia found that students' confidence and self-efficacy in learning new ICT skills were strong predictors of positive views towards e-health. This was particularly relevant at the University of Sydney's Faculty of Health Sciences. Besides, there is a strong link between confidence, self-efficacy, and previous IT learning situations and how people feel about using e-health, according to the researchers (Lam et al., 2014, p. 63). This demonstrates that students' positive views towards technology-mediated health learning depend on both their previous experience with ICT training and their optimism in their ability to learn new ICT tools.

Theme 3 Professional development and pedagogical innovation

ICT's rise means teachers need both tech skills and pedagogical know-how, not just devices. Based on Majumdar's (2015) argument that education is changing from standard classrooms to virtual learning environments, ICT has the power to change everything, this change has affected both students and teachers, putting more emphasis on methods that are student-centered and use technology to assist them learn. ICT makes it possible for educational and teaching environments to be fully merged, which is in line with good teaching practices. Majumdar (2015) says that ICT also changes teachers' roles from passing on information to helping students find information and learning with them, which means teachers need to rethink their standard jobs and methods of teaching and come up with new ways to teach. According to Suárez-Rodríguez et al. (2018), there are two types of ICT competence: technological competence and pedagogical competence. Technological competence includes knowing how to use systems, software, and virtual platforms, and pedagogical competence includes using ICT in lesson planning, communication, and interaction with students. It suggests that ICT training must be both generationally inclusive and pedagogically grounded. Further insights into the professional conditions affecting ICT integration were provided by Hennessy, Harrison, and Wamakote (2010), who examined classroom technology use in Sub-Saharan Africa. Even though the work isn't specifically about Australia, the themes of teacher motivation, environmental support, and leadership involvement are all problems that teachers face in Australia, it found that technology projects often failed when they focused only on giving out tools without providing teaching and guiding help. These outcomes show the necessity that it is for professionals to keep learning how to use technology in a way that fits their needs. Effective teaching methods are needed to help pre-service teachers in Australia learn how to use ICT. Ainley (2010) used data from the 2006 Programmed for International Student Assessment (PISA) to look at how ICT was used for testing in Australian schools. The study also demonstrated that even though schools had much better access to ICT tools, integration in the classroom was still not the same across institutions and subjects. Furthermore, Ainley concluded that having access to technology does not mean that it will be used effectively. Instead, he said that professional growth and new ways of teaching are needed to use ICT to get real educational results. Consequently, the

writers pushed for adding TPACK-focused courses to teacher education programs to encourage the use of ICT in a way that makes sense in the given situation. Jordan (2011) used the TPACK system to test the ICT skills of 64 Victoria teachers-to-be and teachers-to-be-be， the results showed that most of the volunteers knew basic digital skills (like how to use Microsoft Office), but they had trouble figuring out how to use ICT in subject-specific lessons. Making digital learning tasks and using tools that are specific to the subject. This study demonstrated that there is a gap between technical skill and how it is used in the classroom. This shows that teachers need more specialized training in digital teaching.

A review of NSW schools during the Digital Education Revolution (2010–2013) added to the evidence of these results. When teachers got the right training and support, they said their students were more interested, they grew professionally, and they felt more confident. Schools where student results improved significantly usually had teachers who actively used ICT in the classroom. But problems like not having sufficient expertise, not getting enough career growth, and not having enough time to plan were often mentioned. The audit discovered that ICT could improve the standard of training and the speed of professionals if it is used correctly. However, barriers such as limited expertise, insufficient professional development, and a lack of planning time were commonly reported. The audit concluded that with the right support, ICT can improve teaching quality and professional efficiency, though time and resources are critical for maximizing its benefits.

Theme 4 Building Confidence and Self-Efficacy

In 2005, Steketee, Hossain Khan, et al. used interviews and surveys to investigate how Australian TAFE teachers use ICT. Based on data from the International Computer and Information Literacy Study (ICILS), they found that Australian teachers got an average of 55 on the ICT self-efficacy measure (mean = 50, SD = 10), which was higher than the average score for teachers around the world (Fraillon et al., 2014). Teachers under the age of 40 were more confident in a wide range of ICT jobs, such as managing files, sending emails, and using word writing programs. More research, like MDPI (2023), shows that teacher learners over the age of 50 often say they don't have as much confidence in using ICT because they don't have enough training, time, or a good enough platform. Vandeyar and Adegoke (2024) say that pre-service teachers need to have models and be modelled after, because these are important for building confidence and using ICT skills in real classrooms. The Teaching Teachers for the Future (TTF) study, which was looked at by Cheal et al. (2012), polled and talked to Australian future teachers to find out how ready they were to use ICT in the classroom. Findings showed that many teachers were not confident in using ICT for teaching. This was often made worse by partner teachers not being good role models during training and schools not always having access to digital tools. According to the study, ICT integration should be more clearly built into teacher education programs, with a focus on practical skills and how they can be used in the classroom. Besides, Dawson (2008) investigated gender differences and trust problems among science teachers in Western Australia who were just starting out. Using interviews and observations of the classroom, the qualitative study found that male teachers used ICT tools more often and with more confidence than female teachers, even though they had had the same training. The research above found that confidence, not technical skill, was a major factor in ICT integration. As a result, teacher education programs need to focus on the psychological consequences of using ICT, such as boosting students' confidence and encouraging practices that are open to everyone and reduce gender differences. In 2006, Jamieson-Proctor and Finger investigated how pre-service teachers' confidence in ICT was related to their beliefs about how useful it was for education. A study of teacher education students in Queensland showed a strong link between ICT self-efficacy and the possibility of integrating technology into the classroom in the future. Many of the people who answered, though, had limited ideas about how ICT could be used and thought it could only be used for routine chores. The writers emphasized how important it is to be exposed to high-quality ICT practices early on during training programs, they suggested that to encourage more people to use ICT, technical training should happen at the same time as confidence-building. Moreover, A 2013 study by Kim et al. of many U.S. teachers found that teachers' views about how to teach were a strong prediction about the way they would use ICT in the classroom. Teachers who lean towards constructivism were more likely to use ICT in creative ways than teachers who stuck to old ways of doing things, the study wasn't done in Australia, but it shows how important it is for all ICT training to be in line with larger educational ideas. In Australia, teacher education programs could do a better job of talking about how educational views affect how students use technology. In 2021, Pozas and Letzel (2023) used the "Will, Skill, Tool" model to identify the way 103 Australian pre-service teachers would use ICT, the research they did showed that willingness, confidence (self-efficacy), and access to digital tools had a big effect on how people would use ICT in the future. Moreover, Female subjects were a little more nervous about using technology, which shows that different types of training are needed. According to the study, getting hands-on practice and training that was matched with how people learn had bigger benefits on ICT preparation than using digital tools before. These results make it even more important to make sure that ICT lessons are both useful and tailored to the needs of each student.

Theme 5: Pedagogical and Training Deficiencies

In 2010, Finger, Jamieson-Proctor, and Albion added to the TPACK talk by saying that ICT-related educational information should be added to national standards for teachers who want to get certified. Their research showed that ICT training in Australian schools was not at all consistent, and they stressed the need for competency-based systems. They suggested that governing groups set required ICT skills levels that are in line with educational goals. This would make sure that ICT becomes an important part of training. In 2015, Gill, Dalgarno and Carlson looked at how pre-service teachers in Australia improved their ICT skills over the course of a four-year program , through a combination of study methods, they found a development from basic technical use to thoughtful and pedagogically informed ICT use Real-life learning experiences, especially during practicums, were found to be very important for turning pre-service teachers from passive users of technology to creative and critical practitioners. The results show that the long-term, real-world use of ICT tools is for making future teachers who are good at their jobs. As a result, schools that train teachers need to make sure that students learn both professional skills and how to teach. To test future teachers' Technological educational Content Knowledge (TPACK), Albion, Jamieson-Proctor, and Finger (2010) created the Teaching with ICT Audit Survey (TWictAS), this was based on the need for educational alignment. What they found showed that many future teachers were good at using common tools, but not good at using ICT in ways that were specific to their field. As the TWictAS framework shows, trust in ICT use must go beyond basic digital skills and include apps that are useful for teaching.

Even though there have been attempts to include ICT in teacher education in Australia, many problems still exist. In 2009, Goktas, Yildirim, and Yildirim did a study of teacher education schools in Turkey and found problems like poor facilities, a lack of skilled trainers, and not enough homework related to ICT. These results are like what has been found in Australia, where similar structural problems have been recorded. The writers make the case for major changes to institutions, such as greater funds being spent on infrastructure, a new curriculum, and specialized training for teachers to help students learn ICT skills. Besides, another study by Jordan and Elsden-Clifton (2016) polled 69 future teachers to find out how they got and used ICT toolkits, the study found that people learnt basic tools like Google Docs mostly through personal experience. They didn't get much official training in professional platforms like learning management systems (LMS), testing software, and tools specific to their field. The researchers concluded that ICT training in teacher education was still basic and dispersed, which made it harder for future teachers-to-be to use technology successfully in their classes.

Research questions

1. How do Australian pre-service teachers perceive the relevance of ICT skills for their professional readiness and teaching effectiveness?

2. What effective training strategies can improve the ICT skills of pre-service teachers in Australia?

3. What are the challenges faced by Australian pre-service teachers during ICT skills training?

3 Methodology

3.1. Introduction

This chapter goes into detail about the strict methodology used to do this secondary study. The aim was to find out how Australian pre-service teachers think about ICT skills development, what training methods work, and what challenges they face. According to Saunders, Lewis, and Thornhill (2019), the methodology is a complete set of rules and philosophical beliefs that support the research process. It clearly explains how to collect data, analyze it, understand it, and put it all together to make sure it is scholarly sound. The main method used in this study is secondary research, which includes collecting, reviewing, and putting together factual data and theoretical analyses that have already been done without collecting new data (Smith, 2008). The benefit of secondary research is that it can look at a variety of different sources, providing a lot of different points of view, improving understanding of ideas, and giving an expanded view of many different educational issues, especially how to incorporate ICT into initial teacher training programs. This investigation's study strategy is strongly in line with qualitative secondary analysis. According to Johnston (2017), qualitative secondary analysis makes it easier to engage deeply and interpretively with existing qualitative data. This lets researchers place original results within wider theoretical and cultural frameworks. By using this method of reflection analysis, this study puts previous results in a new light and finds new connections between pre-service teachers' ICT skills, how effective they think their training is, and problems in the system.

3.2. research design

3.2.1research philosophy

The research philosophy used in this study is interpretivism, which says that social reality is made up by people interacting with each other and interpreting it. “It is necessary for the researcher to understand differences between humans in our role as social actors” (p. 149), say Saunders, Lewis, and Thornhill (2019). This is what interpretivism means. Also, Bryman (2016) says that interpretivism is a way of thinking that "requires the social scientist to grasp the subjective meaning of social action" (p. 375). In the same way, Willis (2007) says that interpretivism

"tries to understand the world of human experience from the participant's point of view" (p. 96). This study aims to find out how Australian pre-service teachers feel about their ICT skills and professional ready. This philosophy stance fits perfectly with this study's main idea. By using interpretivism, the study tries to figure out not only what can be seen but also what pre-service teachers think about how to use ICT in the classroom, how to train teachers, and other problems that come up in these areas. The interpretivist research method used in this study stresses the importance of understanding the unique views and experiences of Australian teachers-to-be when it comes to ICT skills. For instance, firstly, this method doesn't just count how many pre-service teachers can use technology, it also searches into why some think ICT is important for teaching and others like the old-fashioned way. secondly, the study looks at various situations, like how training jobs are different, to find out why some pre-service teachers are sure they can use ICT and others aren't sure. thirdly, the study gives a full picture of how pre-service teachers think about and use ICT skills by looking at their emotions, goals, and real-life classroom experiences, like fearing using interactive whiteboards or not having enough role models. Instead of looking for one "right" answer, the interpretivist method values and summarizes the different, and sometimes opposing, views that were found among the participants. This shows how complicated teacher training really is.

3.2.2 Research approach

This study uses an inductive research method, which includes building a theory and drawing conclusions that can be applied to other situations from trends found in qualitative data. Thomas (2006) says that "inductive analysis" (p. 238) is a method that uses close views of raw data to find ideas, themes, or a model. These ideas come from how the researcher or reviewer understands the raw data. As Creswell and Creswell (2018) say, an inductive method works best when "the researcher builds patterns, categories, and themes from the bottom up" (p. 63). Braun and Clarke (2006) say that "thematic analysis is a way to find, analyze, and report patterns (themes) in data...usually using an inductive approach" (p. 79). In this study, this means that it doesn't start with any set theories. Instead, this study uses literature and secondary qualitative data to find patterns and theoretical thoughts about how Australian pre-service teachers learn ICT skills. In this study, the inductive approach is carried out in clear steps. First, collect a wide range of literature and qualitative data about Australian pre-service teachers' experiences with ICT skills. Second, read through these materials without any fixed ideas, looking for repeated patterns, stories, or surprising details. For example, while reading, it may notice that many pre-service teachers mention a lack of confidence when using ICT tools in their practicum. Third, these recurring ideas—such as "confidence issues," "lack of training," or "positive experiences with mentor support"—are grouped into themes. Finally, build conclusions and possible theories from these themes, explaining, for instance, why practical experience or mentoring helps pre-service teachers feel more prepared for using ICT in real classrooms. At every step, let the data "speak for itself," allowing new insights to emerge naturally from the evidence.

3.2.3research methodology

Secondary research (also called secondary data analysis) is commonly defined as the use or re-analysis of data collected by others for a different purpose (Smith, 2008); as the systematic analysis of existing quantitative or qualitative datasets to answer new questions (Johnston, 2017); for qualitative materials, as the analytic "reworking" of pre-existing texts, transcripts, or documents (Heaton, 2004). Its main advantages are speed and cost-effectiveness (because it don't have to collect new data), scope (because it can access large, multi-year, or national datasets that a single project couldn't collect), and ethical feasibility (because participants don't have to do as much work and getting permissions is easier when you use openly available or de-identified sources). Qualitative research is an interpretive approach to inquiry that aims to understand how people make sense of a situation in their natural settings. Instead of using numbers to test factors, it collects a lot of rich, detailed evidence, like interviews, observations, papers, and pictures, and builds themes from this. The researcher stays close to the subjects and the situation so that they can be the most important tool. The plan is also flexible so that the study can adapt to new information in the field. As a result, there is a lot of detailed information about meaning, process, and setting, but not much about measurement or prediction (Creswell & Poth, 2018; Denzin & Lincoln, 2018; Merriam & Tisdell, 2016). In this study, the first step is to find and collect several different types of qualitative evidence. These could be written interviews, thoughtful writings, poll results, or government papers about ICT training. Next, looks closely at how ICT is taught, understood, and used in various programs, comparing specifics from different sources. For instance, the study might look at how the hands-on ICT workshops at one school affect students' trust compared to another that mostly uses classes. Besides， find both similar themes and unique problems and answers by looking at these real-life events from different points of view. In the end, this method lets the study "tell the story" Of ICT integration through the eyes of future teachers -to-be, showing the difficulties and wins they faced in their real classrooms.

It searched for studies in a simple, repeatable way. To begin, this study used keywords to look for information in ERIC, Web of Science, ProQuest Education, and Informit (A+ Education). It used plain terms and synonyms, for example: Australia, pre-service teacher / preservice / initial teacher education (ITE), plus ICT / digital technology / TPACK, and training / preparation / practicum / readiness / self-efficacy. The filters were set to "peer -reviewed," "English," and "year 2000 or later." It also used the same search terms to look at Australian government sites (ACARA and the Department of Education) for policy information. First, the title and summary were read, and then the full text was read using our inclusion/exclusion table (Australian PSTs, ITE setting, ICT/TPACK focus; exclude non-AU unless AU data are separate, tool-only pieces, or things before 2000). It took out a small group of fields for each study one can looked at: context (AU/non-AU), sample (N, PST stage), setting (coursework/practicum), measures (e.g., TPACK, confidence), training components (e.g., modelling, hands-on, design, reflection), and results. Lastly, it put the evidence into groups based on research questions (what was thought to be relevant, what worked, and what were the challenges), then looked for patterns or gaps between studies.

3.3 research methods

3.3.1 sampling

A method called "purposive sampling" is used to make sure that the secondary data and works chosen are very useful for Australian pre-service teacher education and integrating ICT. There is a lot of information in some cases that should be studied in more depth, as Patton (2015) says. Sources had to be new, have been reviewed by other researchers, and be specifically about developing ICT skills, training methods, or issues related to teacher education to be included. For this project, firstly, sets strict guidelines for which sources can be used: they must have been written within the last ten years, been reviewed by other researchers, and be specifically about pre-service teacher education and ICT skill development in Australia. For instance, the researcher might give more weight to current government reports on teacher training or academic studies that compare how different Australian schools use ICT. By using these standards, the sample method makes sure that all the data being looked at is reliable, up-to-date, and directly related to the problems and solutions that pre-services teachers are facing. Targeted research like this makes the study's results more reliable and in-depth.

3.3.2 Data collection

Secondary data collection is the only source of information used in this study. "Use of existing data collected for the purpose of another study" (Smith, 2008, p. 1) is what secondary research is. Journal articles, official government studies, and large-scale poll records about ICT skill growth among Australian teachers-to-are some of the sources of data. Keyword searches were used to find the data in a planned way in reliable sources like ERIC, JSTOR, ProQuest, and government education sites.

3.3.3 data analysis

Thematic analysis method is used to find trends in the data and figure out what they mean. Braun and Clarke (2006) say that thematic analysis is "a way to find, analyze, and report patterns (themes) in data" (p. 79). By using hand-coding to group important parts into main themes, like how people see the usefulness of ICT, teaching methods, and challenges. This way also makes it easier to find new results and important holes in the literature. In particular, the method is used by carefully reading and categorizing research studies, policy papers about the ICT skills of Australian teachers-to-be. this study used an inductive thematic analysis (six-step process: familiarization → coding → theme generation → review → define/label → write-up) to bring together findings from multiple studies and reports in the document. Each theme below was kept only if it showed up in more than one separate source (qualitative cases, poll reports, TPACK studies, or SQD/SQD2 summaries). To make sure that each group was backed up by more than one paper in the file, hand-coding and a small proof matrix were used.

Category 1 — Perceived value vs classroom readiness

These are the studies that show PSTs really value ICT but aren't ready to teach with it. The group comes from national/cohort polls and TPACK studies that show that most people agree that ICT is important (see Cheal et al. and John et al. numbers), but few people think they can use ICT to teach or help students use it. These patterns show up many times in the file and were put together to make a single theme (value ≠ readiness).

Category 2 — Effective training

The paper includes several intervention and review studies that all come to the same conclusion: good planning usually includes several different parts, such as modelling, hands-on exploration, instructional design tasks, real-life practice like microteaching, feedback, and guided reflection. This group includes the SQD/SQD2 summaries and the meta-aggregation

of 28 qualitative studies that say planning, discovery, and reflection work best together. It also includes intervention examples like digital stories or project work. It put these sources together because they kept showing up in places where things got better.

Category 3 — Opportunity-to-learn (OTL) and program structure

It put together data that shows that ITE programs often offer more chances for learning how to teach than for specific technological or techno-pedagogical practice. TPACK studies by Heine et al., and course/practicum accounts show that instructional knowledge grows while pure TK falls. This suggests that uneven OTL may help explain some of the readiness gap. The code for these different sources in the file was put together to name program design as a structural reason.

Category 4: Limitations in the environment and changes in self-efficacy

This group connects problems at school or in the practice (such as broken or limited technology, the quality of the guide, the make-up of the class, and language barriers) with changes in PSTs' confidence. It used survey results (Figure 7 analyses, DST and computational-thinking cases) to show that trust goes up when there is good mentoring and down when the situation isn't solid. These repeating patterns from various qualitative studies were put together to show why the same training can lead to different results in real life.

3.4 Ethical consideration

Ethical issues are important in all research because they protect the rights, respect, and well-being of all subjects and keep the study itself honest. Israel and Hay (2006) say that "ethics in research" means the moral rules that guide study from the beginning to the end and the release of the results (p. 1). Ethical research means following moral rules and professional codes of behavior when gathering, analyzing, reporting, and sharing information about people who took part in research (Diener and Crandall, 1978, p. 19). Resnik (2018) says that research ethics are "the rules for behavior that make clear what is and isn't acceptable behavior in scientific research" (p. 1). "Ethical research protects participants from harm, ensures informed consent, maintains confidentiality, and upholds the honesty of the research process" (p. 111) is what Cohen, Manion, and Morrison (2018) say about educational research. Everything that was used as secondary data in this study was collected and reported in full compliance with these rules. There were no main data collection activities involving people, which lowers the risk of direct harm or privacy breaches. Still, the study shows respect for the original sources by properly citing all results and not plagiarizing. Furthermore，The University of Birmingham's most recent ethical rules can be found in "Code of Practice for Research" (University of Birmingham, 2023) and are in line with this study. As required by the University, researchers must (1) use data responsibly and not misrepresent it, (2) give credit to all sources and contributors, (3) be open and honest when analyzing and reporting results, and (4) follow all copyright and intellectual property laws. By following the original authors' legal and moral rules and the University's guidelines on study integrity and good academic practice (University of Birmingham, 2023) any use of secondary data must be legal and moral. Following these rules not only keeps the study's academic and moral standards high, but it also shows what kind of professional and moral duties people in the field of educational research are supposed to have.

3.5 Limitation

One notable limitation of this study's methodological approach is the dependency on published literature and reported secondary sources, which may introduce bias in selection or eliminate critical recent developments not yet covered in the literature (Johnston, 2017). Because initial data collection wasn't done, it wasn't possible to get real-time comments from participants to confirm views or to get more information when data wasn't clear. Also, putting together themes from different sources may be messy because meanings, research methods, and standards for reporting often vary from one study to the next (Silverman, 2013). Lastly, because theme analysis is subjective, it is impossible to avoid researcher bias. This could affect which results are emphasized and how conclusions are presented. When thinking about the study results' reach and effects, these kinds of limits should be considered.

This study adopts a quantitative research design that integrates real-world correctional datasets with explainable machine learning techniques to develop and evaluate a transparent recidivism risk prediction framework. The analysis begins with the collection and preprocessing of offender-level data obtained from a correctional institution in Eastern Europe, including demographic attributes, criminal history, institutional conduct, and post-release supervision records. Extensive data cleaning procedures are applied to address missing values, inconsistent entries, and categorical variables, ensuring that the dataset is suitable for machine learning modeling. Following preprocessing, the data is partitioned into training and testing sets to enable rigorous model validation and to prevent information leakage.

The modeling component of the research employs a set of predictive algorithms chosen for their ability to capture nonlinear relationships and heterogeneous risk patterns. These include Gradient Boosting Machines, Random Forests, and the Explainable Boosting Machine (EBM), which provides an inherently interpretable structure grounded in additive modeling. To enhance transparency across all models, SHAP values are used to generate feature-level explanations that quantify each variable's contribution to the predicted risk of reoffending. Model training relies on cross-validation to optimize hyperparameters, while performance is assessed using standard metrics such as accuracy, AUC, precision, recall, and F1-score. These metrics allow for a balanced evaluation of predictive capability, particularly given the potential class imbalance between recidivists and non- recidivists.

In addition to predictive evaluation, the study incorporates a systematic interpretability analysis to examine how different offender characteristics influence model decisions. SHAP-based global and local explanations are analyzed to identify the most influential factors and to understand how these variables shape individualized risk profiles. This dual focus on prediction and interpretability ensures that the final model is not only empirically robust but also capable of providing transparent reasoning suitable for operational use in correctional decision-making. Through this methodological approach, the research advances a rigorous and ethically aligned framework for employing explainable machine learning in recidivism risk assessment.

Table 1. Core Institutional Features: Comparative Baseline

Dimension	Germany	France	Italy
State Structure	Federal System (16 Länder)	Centralized State (Jacobin tradition)	Fragmented Pluralism (Regional divisions)
Rule of Law Index	0.87/1.0 (Strong)	0.71/1.0 (Moderate-Strong)	0.48/1.0 (Moderate)
Judicial Organization	Decentralized (16 state prosecutors + BKA)	Specialized & Centralized (PNF, AFA, HATVP)[2]	Overburdened but Independent (+23% case backlog 2023)
E-Procurement Coverage	89%	Comprehensive digitalization	Emerging systems
System Interoperability	67% (inter-state)	100% (centralized)	Developing
Law Enforcement Efficiency	Moderate (28-month processing cycle)	High (78% case closure rate)	Volatile (case-dependent)
Administrative Capacity	Mature (institutionalized)	Strong (state-driven)	Developing (digital compensation)
Core Mechanism	Legal precision + Federal coordination	State authority + Institutional innovation	Digital innovation + Institutional compensation
Expected Implementation Pattern	Institutionalized Robustness	Efficacy-Oriented State-Led	Digitally-Driven Compensatory

Note: Data sources include Transparency International (2023), nationaljudicial statistics (2023-2024), and anti- corruption agency reports.

Germany's cooperative federalism and its strong tradition of the rule of law have shaped a way of implementing the law that emphasises legal precision, procedural legitimacy, and coordination between states. The country's strong legal independence and its system for prosecuting crimes, which is spread across the country, show that the law is formalised but may not always be applied in the same way(Wolf, 2021) .

In France, the state-driven implementation model has been supported by the interventionist administrative style and centralist tradition of governance. One

distinctive French approach to accomplishing policy objectives through new institutions and centralized action is the establishment of more specialized organizations, such as the Office of the Prosecutor for Financial Crimes, with public trust in such agencies being a key factor(Monnery & Chirat, 2024).

Italy's laws and regulations are complicated and many are corrupt. The government is often changing the rules, the administration is disorganised and the court system is overworked and cannot make its own rules. In response, Italy has developed a 'technological empowerment' strategy to combat corruption. The National Anti-Corruption Authority (ANAC) is developing new initiatives, such as secure online platforms for reporting corruption and straightforward systems for online purchases. These are innovative solutions for the problems caused by fraud in the system (Feldman, 2020).

The research considers different cases and employs a variety of research techniques in order to gather information. The research incorporates both qualitative and quantitative research techniques to make findings reliable while maintaining a strong qualitative background. For example, the research incorporates both qualitative techniques, such as personal conversations, as well as quantitative elements, like numerical data (Flick, 2022). Rather than relying only on quantitative data in regression models, we use it to corroborate patterns identified through qualitative analysis, thus enhancing our ability to discern causal relationships.

This paper examines the adoption and implementation of the EU Anti-Corruption Directive in Germany, France, and Italy. We provide evidence based on a comparison and discussion of how the institutional framework of each country shapes the effectiveness of the Directive.

Building on this methodological foundation, the study further incorporates several advanced procedures to ensure the robustness, fairness, and practical applicability of the predictive models. After initial data preprocessing, feature engineering is conducted to transform raw correctional records into meaningful predictors. This includes deriving aggregated behavioral indicators from institutional misconduct logs, generating time-based variables that capture the duration of incarceration or supervision, and encoding socio-economic information extracted from narrative case files. Correlation analysis and variance inflation diagnostics are performed to reduce multicollinearity, while feature selection techniques such as mutual information and model-based importance measures help refine the final set of input variables. These steps ensure that the models are trained on stable, informative features that represent criminologically relevant constructs.

To address potential data imbalance—common in recidivism datasets where non-reoffenders often outnumber reoffenders—the study evaluates several sampling strategies, including SMOTE synthetic oversampling and class-weighted learning. The goal is to prevent the models from developing a bias toward majority-class predictions and to ensure that high-risk individuals are correctly identified. The models are then trained using repeated k-fold cross-validation to provide an unbiased estimate of performance and to minimize the variance associated with a single random partition. Hyperparameters for each algorithm are optimized using Bayesian optimization, which offers a more efficient and theoretically grounded search strategy compared with grid search or random search.

Beyond performance measurement, the study emphasizes interpretability by conducting multi-layered explanation analyses. For intrinsically interpretable models such as EBM, shape functions are examined to visualize how each feature influences the predicted outcome across its entire range. For more complex ensemble models, SHAP summaries, dependency plots, and force plots are generated to illustrate variable interactions and individualized risk explanations. This step is essential for ensuring that the model does not inadvertently rely on proxies for protected characteristics, such as ethnicity or socio-economic background, thereby addressing fairness and ethical concerns in criminal justice applications.

The research design also incorporates a comparative methodological component, where traditional actuarial methods—such as logistic regression and rule-based scoring systems—are benchmarked against the machine learning models. This comparison highlights the value added by modern algorithms in capturing nonlinear effects and interaction structures that traditional models cannot accommodate. Additionally, calibration analysis is performed to assess whether predicted probabilities accurately reflect observed reoffending rates, an important requirement for models used in decision-making contexts. Poor calibration can lead to overestimations or underestimations of risk, which may influence correctional outcomes unfairly. By examining calibration curves, Brier scores, and reliability diagrams, the study ensures that the proposed models not only perform well but also produce trustworthy probability estimates.

Finally, the research evaluates the practical viability of deploying the explainable models within correctional institutions. This involves simulating how risk predictions might be integrated into existing assessment workflows and examining how interpretability outputs, such as SHAP explanations, can assist officers, case managers, or psychologists in understanding individualized risk factors. The methodological approach therefore extends beyond model accuracy to consider usability, transparency, and alignment with ethical guidelines for data-driven criminal justice tools. Through this comprehensive and multi-layered design, the study establishes a rigorous empirical foundation for assessing the role of explainable machine learning in recidivism prediction and provides a replicable methodological blueprint for future research.

4 Results and Analysis

Research question1. How do Australian pre-service teachers perceive the relevance of ICT skills for their professional readiness and teaching effectiveness?

Table 1 Sample characteristics

From: **Preservice teachers' professional knowledge for ICT integration in the classroom: Analysing its structure and its link to teacher education**

	Bachelor						Master					
	Population		Sample		Included for analyses		Population		Sample		Included for analyses	
n	1249		386		320		737		316		299	
Teaching programme type	*N*	%	*n*	%	*n*	%	*N*	%	*n*	%	*n*	%
Primary Schools	154	12.3	58	15.0	53	16.6	104	14.1	49	15.5	45	15.1
Lower Secondary Schools, Intermediate Secondary Schools, and Comprehensive Schools	226	18.1	67	17.4	55	17.2	109	14.8	43	13.6	38	12.7
Grammar Schools and Comprehensive Schools	421	33.7	114	29.5	88	27.5	232	31.5	104	32.9	99	33.1
Vocational Colleges	61	4.9	20	5.2	12	3.8	59	8.0	24	7.6	23	7.7
Special Needs Education	387	31.0	127	32.9	112	35.0	233	31.6	96	30.4	94	31.4
	%		%		%		%		%		%	
Gender (female)	74,7		80.1		81.3		77,6		78.5		78.9	
			M	*SD*	*M*	*SD*			*M*	*SD*	*M*	*SD*
Age			21.3	3.4	21.2	3.3			25.9	3.8	25.9	3.9
GPA			2.1	.6	2.0	.6			2.2	.6	2.2	.6

Information on mean age and GPA of the population was not available

Table 2 Item examples from the GPK, TPK, and TK tests

From: **Preservice teachers' professional knowledge for ICT integration in the classroom: Analysing its structure and its link to teacher education**

Knowledge area	Item example	Correct solution
GPK	Which of the following cases represents an example of intrinsic motivation, and which represents an example of extrinsic motivation? Check one box in each row (Response Categories: Intrinsic Motivation, Extrinsic Motivation) A student learns before a test in mathematics, because he/she... a) expects a reward for a good grade b) wants to avoid the consequences of a bad grade c) is interested in problems of mathematics d) does not want to disappoint his/her parents e) wants to maintain his/her relative rank in the class	Intrinsic motivation: c) Extrinsic motivation: a), b), d), e)
TPK	You give your students an extensive research task on the Internet over several weeks. The results are saved in the form of several image and text files and are then to be sent to you as an e-mail Which of the following files was saved by the group in a space-saving way? a) Research.zip b) Research.csv c) Research.rtf d) Research.pdf	a)
TK	Students are doing research for an assignment in class and click 'agree' directly when asked to accept cookies. You want students to think about this behaviour and give them hints. Which hint is wrong? a) By going to the settings in the pop-up window, you can select which cookies to allow with restrictions b) After installing a cookie dialog blocker on a computer, all cookies are automatically blocked c) Cookies can be managed through the browser d) There is a setting that decrees that cookies are automatically deleted after each session	b)

The study's results show that pre-service teachers' professional knowledge for using ICT in the classroom can be broken down into three separate areas: general pedagogical knowledge (GPK), technological pedagogical knowledge (TPK), and technological knowledge (TK). Based on the work of Heine et al. (2024), data from 619 future teachers shows that these areas are somewhat connected, but they can be separated and shouldn't be thought of as a single concept, which fits with the TPACK framework. In all areas of knowledge, master's students do much better than bachelor's students, according to the study. This suggests that teachers with more schooling are better at using ICT in their jobs. Besides, the study's most important finding is that opportunities to learn (OTL) in teacher education programs are not spread out evenly. Opportunities to learn about pedagogy have a positive and significant effect on the development of general pedagogical knowledge, but opportunities to learn about technology and how to use technology in teaching are not provided enough and do not have a significant relationship with test scores. For example, only about 30% of master's students said they had been exposed to modern, and the numbers were even lower for some subject areas. These data show that, despite changes to the curriculum, most pre-services teachers don't have many organized chances to learn advanced ICT skills. There is a strong case for expanding and systematizing technological and technological-pedagogical learning possibilities in teacher education programs right away. This will make sure that pre-services teachers are ready to meet the needs of a digitalized education system. Heine et al. (2024, p. 11043–11075) say that "the three knowledge facets can be empirically separated," and they say that the fact that there isn't any structured OTL in key technological areas right now is a big problem with how teachers-to-be are prepared.

Table 1: Selected national survey data

Category	Mean	Standard Deviation
confidence in using ICT for teaching	4.16	.907
usefulness of using ICT for teaching	5.30	.734
confidence that they can facilitate their students use of ICT for learning	3.59	.929
usefulness for their future students using ICT for learning	5.25	.828

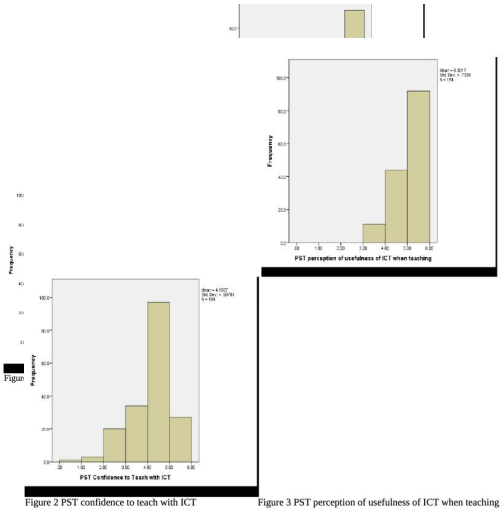

Figure 2 PST confidence to teach with ICT

Figure 3 PST perception of usefulness of ICT when teaching

Figure 2 PST confidence to teach with ICT

Figure 3 PST perception of usefulness of ICT when teaching

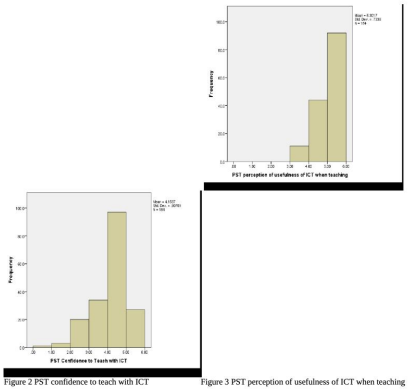

Figure 2 PST confidence to teach with ICT

Figure 3 PST perception of usefulness of ICT when teaching

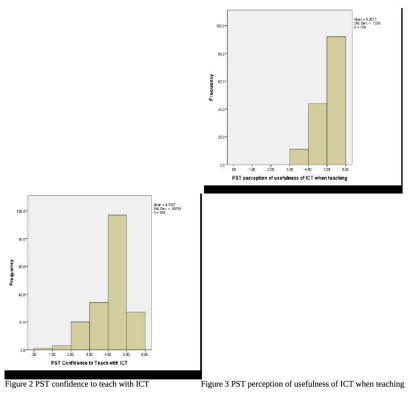

Figure 2 PST confidence to teach with ICT

Figure 3 PST perception of usefulness of ICT when teaching

Cheal, Geer, and White's (University of South Australia) study gives us a complex picture of how ready and how they feel about using ICT in the classroom among Australian pre-service teachers. A survey of 198 final-year pre-service teachers found that most of them agreed that ICT could be useful for both teaching (mean = 5.30, SD = 0.73) and student learning (mean = 5.25, SD = 0.83). However, these pre-service teachers were much less sure that they could use ICT for teaching (mean = 4.16, SD = 0.91), and they were even less sure that they could help students use ICT for learning (mean = 3.59, SD = 0.93). The difference between the two shows a big problem: future teachers know that ICT can help with learning, but they're not sure how to use it in a real classroom.

This in-depth scoping review looked at 277 empirical studies from 2000 to 2024 to take a picture of what pre-service teachers think about ICT, what they study, and how they do their research in different parts of the world. 60% of the included works were quantitative studies, 25% were mixed methods studies, and only 15% were qualitative designs. This shows that there is a methodological bias towards standardizing how ICT attitudes are measured, most often through the Technology Attitude Scale and similar instruments. There were seven main research themes that came out. Most of the studies (62% of them) were about general ICT beliefs. Other studies looked at ICT training programs (13%), technology competence and digital literacy (8%), comparing ICT beliefs across regions or between pre-service and in-service teachers (4%), relationship studies (5%), ICT belief modelling (4%), and how people feel about ICT-based teaching and learning (4%). Most studies didn't say which ICT tool was used, but computers (17%) and general ICT use (58%) were the most common. The internet, digital stories, wikis, and a small number of studies that talked about newer technologies like VR, AR, and AI were also mentioned. Indicating that ICT technology is widely involved in the education system and provides meaningful guidance for teachers' professional development.

Table 1. Descriptive scores for Content Knowledge by year level (Standard Deviations in Brackets)

Year	Average Content Knowledge Score (Standard Deviation)
1st	3.9 (1.6)
2nd	4.1 (1.6)
3rd	4.9 (1.2)
4th	5.3 (1.2)

Table 2. TPACK inter-scale correlations. * Denotes Significance at the $p < .01$ level

	PK	TK	TPK	CK	TPACK
PK	1	.522*	.690*	.820*	.721*
TK	.522*	1	.806*	.577*	.826*
TPK	.690*	.806*	1	.662*	.900*
CK	.820*	.577*	.662*	1	.743*
TPACK	.721*	.826*	.900*	.743*	1

Australian university. Of these, 192 were women and 63 were men. They were in four different teacher education programs. A TPACK-aligned Likert scale questionnaire was used to find out about five types of information (PK, CK, TK, TPK, and TPACK). Table 1 (p. 120) shows that Pedagogical Knowledge (PK) increased the most from Year 1 to Year 4, going from M = 4.6 (SD = 1.5) in Year 1 to M = 5.5 (SD = 0.97) in Year 4. This shows that teachers are becoming more aware of how to teach. Knowledge of how to use technology in the classroom (TPK) also got a lot better, with the biggest jump happening from Year 2 (M = 4.1) to Year 3 (M = 4.9) (Table 2, p. 121). Technological Knowledge (TK), on the other hand, stayed about the same (M = 4.4) over the four years, with no statistically significant rise (F = 1.3, p =.26). Even though these students weren't technically ready, the fact that their combined knowledge was going up shows that they thought ICT was important for learning and would become more useful as they got better, even if they weren't very confident in using it.

Again, this study used a group of 255 future teachers to look more closely at how their views on ICT were affected by their age, gender, and the place where they lived. The study used TPACK to test students and found that their scores got better over the years, but they didn't hit an "ideal threshold" by the last year, which means they were partially prepared but not fully. Scores are broken down by year in Table 1 (p. 120), and Table 2 (p. 121) shows that gains in combined knowledge are greater than gains in pure technology skills. One interesting result was that male students (M = 4.7) had slightly higher TK scores than female students (M = 4.3), though this difference wasn't really that important (p =.072). Surprisingly, students who had easier access to computers or iPads scored lower on TPACK. This shows that having access to devices does not guarantee that they can be used in the classroom; in fact, if they are not properly facilitated, they may distract students or replace greater learning. Overall, students thought that ICT was useful in the classroom, but they needed a lot of organized help and contextualized modelling to be able to use it. They couldn't just figure it out on their own.

Q19_C. Demonstrate how ICT can be used to support numeracy learning (12)	46.638	1	0.000
Q19_C. Design ICT activities that enable students become active participants in own learning (13)	66.427	1	0.000
Q19_C. Select & use variety of digital media & formats to communicate info (14)	38.768	1	0.000
Q19_C. Evaluate how ICT use has helped teach specific subject area goals (15)	68.665	1	0.000
Q20_C. Engage parents & families in child's school through ICT (16)	55.170	1	0.000
Q20_C. Manage challenging student behaviour by encouraging responsible use of ICT (17)	53.660	1	0.000
Q20_C. Digital citizenship to promote student demonstrate of rights & responsibilities in use of digital resources & tools (18)	89.908	1	0.000
Q20_C. Demonstrate understanding of safe, legal & ethical use of digital info & technology (19)	25.151	1	0.000
Q20_C. Identify personal & professional learning goals in relation to using ICT (20)	65.759	1	0.000
Q20_C. Reflect on relevant ICT research to inform professional practice (21)	77.940	1	0.000
Q20_C. Use range of ICT resources & devices for professional purposes (22)	34.948	1	0.000

This study uses a survey to look at how confident pre-service teachers say they are in their ability to use ICT to teach. The exact sample size isn't given, but the people who answered come from all four-year levels and are typical of groups in Australian ITE schools. Only 34.1% of those who answered said they were "very confident" in their ability to use ICT tools successfully. Notably, students' trust levels grew over the course of the practice. For example, students in Years 3 and 4 were more comfortable using technology than students in Years 1 and 2. Importantly, students who saw their professors explicitly using ICT said they had greater views that ICT would be useful in their future jobs as teachers. Even though the exact numbers for each group aren't given, the trend makes it clear that theory alone doesn't have much of an effect on confidence and, by extension, on

how ready someone thinks they are to work as a professional. The study's conclusion is that most students know how important ICT is, but they don't feel like they can use it until they see it being used in real life at school or university.

John et, al (2025) used Likert scale polls to get objective evaluation data from a group of pre-service teachers from different fields (exact sample number not given). 78% of those who answered agreed that ICT will be "essential" for them as teachers in the future. However, 61% said they didn't have enough training in digital teaching, and only 22% were sure they could use ICT for testing in the classroom. These numbers show that there is a big difference between how professionals see the value of ICT and how ready they are to use it. The study also found that students in the first two years (Years 1 and 2) had the least trust, especially when ICT was taught by itself or only focused on technical tools. The writers say that if educational application isn't emphasized and built in early on, pre-service teachers might see ICT as something vague or outside of their teaching who they are. The results show that ICT training needs to be a part of every subject, especially when teachers are first starting to learn how to teach.

2. What effective training strategies can improve the ICT skills of pre-service teachers in Australia?

In Table 5, we can see how much each SQD-model training strategy—role modelling, reflection, teaching design, teamwork, real-life experience, and feedback—affected preservice teachers' progress in different areas of TPACK practice. In general, most of the methods had positive values, but only a few were statistically significant. Notably, reflection was the only strategy that had a significant positive effect on "infusing ICT into teaching contexts" ($\beta = 0.59$, $p = 0.027$). This means that preservice teachers who did more in-depth reflective activities during their training were better able to imagine and use ICT in real classrooms. On the other hand, role modelling had a statistically significant negative effect on "applying ICT to instructional management" ($^2 = –0.47$, $p = 0.03$). This suggests that either the way role modelling was used in this module may not have helped participants learn management-related ICT skills enough, or they relied less on examples given by the role models when integrating technology.

Table 5 Effect Sizes of SQD-training Strategies on TPACK-practical

From: Evaluating the effectiveness of a preservice teacher technology training module incorporating SQD strategies

	1	2	3	4	5	6	7	8	9
Role modeling	−0.40	−0.27	−0.29	−0.36	−0.36	−0.47*	−0.39	−0.40	−0.40
	(−1.85)	(−1.24)	(−1.34)	(−1.63)	(−1.64)	(−2.23)	(−1.78)	(−1.80)	(−1.87)
Reflection	0.50	0.46	0.48	0.28	0.27	0.47	0.59*	0.28	0.48
	(1.95)	(1.78)	(1.87)	(1.08)	(1.05)	(1.87)	(2.28)	(1.07)	(1.87)
Instructional design	0.02	−0.45	−0.40	−0.42	−0.52	−0.47	−0.25	0.08	−0.33
	(0.08)	(−1.61)	(−1.43)	(−1.50)	(−1.90)	(−1.77)	(−0.88)	(0.27)	(−1.22)
Collaboration	0.10	0.26	−0.04	0.21	0.23	0.16	−0.02	0.14	0.14
	(0.39)	(1.02)	(−0.14)	(0.83)	(0.90)	(0.64)	(−0.07)	(0.53)	(0.53)
Authentic experience	0.26	0.28	0.55	0.46	0.48	0.47	0.35	0.13	0.41
	(0.94)	(1.01)	(1.99)	(1.68)	(1.77)	(1.77)	(1.26)	(0.45)	(1.52)
Feedback	−0.15	0.04	0.01	0.12	0.20	0.16	0.01	0.09	0.06
	(−0.71)	(0.18)	(0.05)	(0.58)	(0.94)	(0.79)	(0.05)	(0.41)	(0.27)
Constant	−1.31*	−1.36	−1.26	−1.35	−1.02	−1.17	−1.38	−1.48	−1.30
	(−2.01)	(−1.78)	(−1.62)	(−1.45)	(−1.21)	(−1.49)	(−1.63)	(−1.68)	(−1.83)

Note: *t* statistics in parentheses; * $p < .05$; coefficients were standardized
1: Using ICT to understand students; 2: Using ICT to understand subject content; 3: Planning ICT-infused curricula; 4: Using ICT representations to present materials; 5: Using ICT-integrated teaching strategies; 6: Applying ICT to instructional management; 7: Infusing ICT into teaching contexts; 8: Using ICT to assess students; 9: TPACK-practical

For the other parts of TPACK-practical, like using ICT to learn about students, planning lessons with ICT, or using ICT for testing, none of the SQD strategies had big effects. However, authentic experience and reflection both had moderately positive coefficients in several areas. It's clear from these results that reflection is the best SQD strategy for helping future teachers use ICT in meaningful ways in the classroom. Other strategies, like collaboration, instructional design, and real-life experience, had a generally positive effect, but it wasn't statistically significant in this sample. The fact that role modelling hurts educational management suggests that watching others use ICT is not enough to learn complex management skills; instead, more hands-on, situation-specific help may be needed.

The study's Figure 1 shows how the three main ways of teaching teachers how to use technology before they start working as teachers (standalone technology courses, tasks that are built into the curriculum, and teacher educators showing students how to use technology) relate to each other. These three ways were found through talks with teachers. The figure shows that all three training methods mostly help pre-service teachers learn basic technical skills rather than understanding how to use technology in a creative or constructivist way in the classroom. The study found that stand-alone technology classes are the most popular way to train people. These courses teach basic ICT skills and terminology, but most people think they are not enough to prepare teachers to use technology to help students learn. Using ICT tools in projects and lesson planning is an example of a curriculum-integrated activity that gives future teachers real-world practice with using technology in the classroom. Teacher trainers who use technology in their own lessons can also affect the confidence and drive of future teachers. However, as Figure 1 shows, this kind of modelling tends to support teacher-centered uses of technology rather than new ways of teaching.

Figure 1. Relationship among the three pre-service technology training methods.

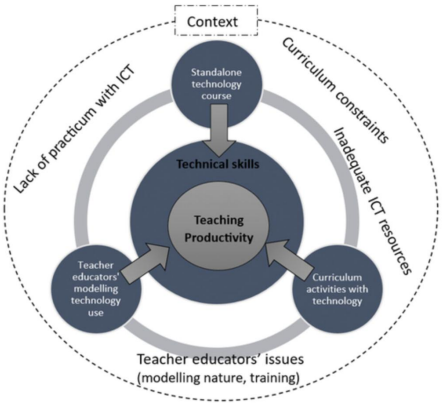

Figure 1's main point is that these methods improve teachers' technical skills and get them ready for basic technology use, but they don't do enough to help teachers build the teaching skills needed for useful, student-centered technology integration. The diagram shows how these approaches fit into a bigger picture that is shaped by limited curriculum, inadequate ICT resources, lack of teacher educator expertise, and limited practicum experience. These factors all contribute to a focus on technical skills and limit chances to develop more advanced teaching methods. As a result, as the graph shows,

teacher education in Ghana puts technical output ahead of changing the way lessons are taught. This means that there is a big difference between how policies want ICT to be used and how teachers are trained before they start working. The authors conclude that major changes need to be made unless pedagogical training and model constructivist technology practices are explicitly integrated into teacher preparation programs, pre-service teachers will not be ready to use ICT to improve student learning in line with 21st-century educational goals.

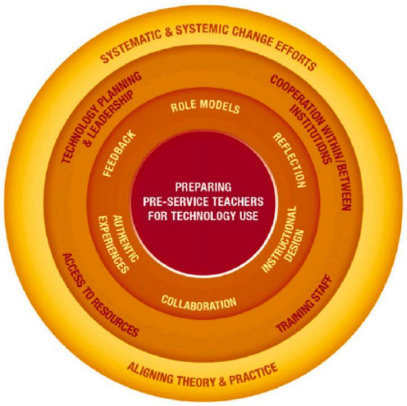

Fig. 1. Synthesis of Qualitative Data (SQD) model (Tondeur et al., 2012).

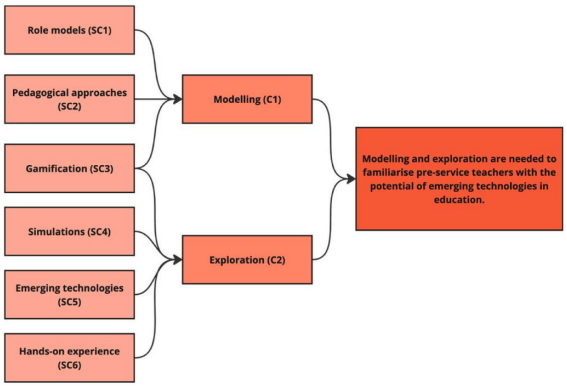

Fig. 3. Categories contributing to synthesis 1.

This research is an organized look at 28 qualitative empirical studies from around the world, including Australia, from 2012 to 2024. Its goal is to make the original SQD (Synthesis of Qualitative Data) model more up-to-date by creating a new SQD2 framework 。 The study uses PRISMA methods and JBI meta-aggregation to find seven micro-level training strategies: role modelling, reflection, instructional design, teamwork, real experiences, feedback, and digital identity/affective engagement (p. 9). The frequency coding matrix (Figure 3) shows that "modelling + exploration" was the most common route. More than 60% of student teachers felt more confidence using ICT tools after watching mentors use them. A technique called "hands-on exploration" was emphasized in 17 of the 28 studies. This shows how important tactile learning is for mastering ICT. For instance, in Schina et al. (2021), teacher candidates who worked with educational robots and Scratch said they felt a lot more confident using ICT in the classroom. The results clearly show that strategically combining modelling, practice, scaffolding, and feedback is a good way to get future teachers ready to use ICT in the classroom, especially in teacher education systems like Australia's and others like it.

Table 2
Phases of the DST project

Phase	Topic of the session	Academic year 2019-2020 – 2nd semester
		Feb. Mar. Apr. May Jun.
Phase 1	Framing the topic: selecting the topic and conducting research	
Phase 2	Structuring the story: elaborating and analysing their story	
Phase 3	Creating the story: building and editing the video	

Table 3
Participants' background characteristics

Participants	Didactics course	Gender	Age
P1. Rose	Social Sciences, History, Behavioural Sciences	F	50+
P2. Armand	Social Sciences	M	30+
P3. Bern	History	M	40+
P4. Angèle	Social Sciences and Behavioural Sciences	F	20+
P5. Eliseo	Social Sciences and Behavioural Sciences	M	20+
P6. Cora	History	F	20+
P7. Kevin	Behavioural Sciences	M	20+
P8. Ana	Behavioural Sciences	F	40+
P9. Helga	Social Sciences	F	30+
P10. Laurent	Behavioural Sciences	F	20+
P11. George	Art History	M	30+

Digital storytelling (DST) on 60 master's students at a Belgian university that trains teachers were investigated in this study. The DST method fits with current trends in digital teaching around the world and can be easily used in Australian settings. The DST project had three parts: choosing a topic and doing study on it, writing a story, and digital production (p. 4, Table 2). The study used Ennis's (2015) 18-category critical thinking framework to code reflection transcripts from 11 in-depth interviews. It then took 149 different pieces of evidence from four main skill areas (p. 6). Notably, students said they were better at putting together pieces of knowledge, using visual media tools, and sharing their ideas about how to teach through multimedia forms. The writers conclude that DST improves both technical ICT fluency and pedagogical expression. This is especially true for tasks that require a lot of thought, like editing videos, combining different types of media, and writing thoughtful narratives. These results show that DST is still useful as an ICT training method that encourages creativity, critical thought, and multimodal literacy — skills that are necessary in modern Australian schools.

3. What are the challenges faced by Australian pre-service teachers during ICT skills training?

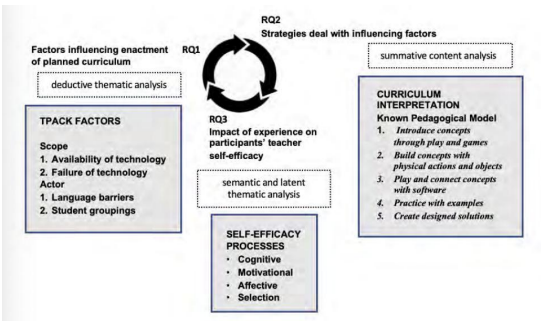

Figure 7: Research questions and guide to analysis frameworks.

Figure 7 shows a visual framework that connects each research question to the specific methods used to analyze the qualitative data in the study. It shows how the study was planned to carefully break down the many-layered experiences of Australian teachers-to-be as they tried to teach coding and computational thought in a Malaysian setting, they were not familiar with. The picture shows that the factors affecting the implementation of the curriculum (RQ1) were studied using logical theme analysis with set aspects of "scope" (like technology availability and failure) and "actor" (like language hurdles and student groups). We looked at the methods used to deal with these factors (RQ2) using final content analysis. This showed a fluid, iterative process where future teachers were always changing their plans and ways of teaching to fit the needs of the situation. For instance, when technology broke down, people turned to offline activities and other digital tools. When language issues came up, people turned to play-based and visual communication.

Figure 7 shows that both semantic (surface-level) and implicit (underlying) theme analysis were used to investigate the effect on pre-service teachers' self-efficacy (RQ3). The researchers were able to understand not only what the subjects said about their confidence and skills, but also how their self-belief and professional identity changed because of their real-life experiences. Figure 7 shows how these different analysis methods were put together to show how the study looked at things in a broad and context-sensitive way. It shows that pre-service teachers increased self-efficacy wasn't just due to good lesson planning; it was also due to sticking with things even when things went wrong, working together with people from different languages and cultures, and thinking about both problems and solutions.

Overall, the data plotted in Figure 7 shows that teaching pre-service teachers how to use ICT and giving them confidence is a difficult process that is affected by problems that teachers face in the real world, the strength of their support systems, and their chances to practice in new ways and think about what they are doing. This way of looking at data makes sure that the study's findings about how ready teachers are and how long it takes to create good code and computational thinking lessons are based on a thorough, multidimensional examination of qualitative data.

5 Discussion

The facts are used to put RQ1 (perceptions of value) in its proper place. Pre-service teachers (PSTs) in Australia consistently perceive ICT as highly relevant to their professional readiness and the success of their teaching, but the level of readiness is not uniform. The chances to learn (OTL) are different for bachelor's and master's students. Master's students do better than bachelor's students. There aren't many technological or tech-ped OTL that can predict TK/TPK (only 30% of master's students said they had used newer tools), but pedagogical OTL can predict GPK. There is clear proof for RQ1 that this shows the relevance–readiness gap is caused by the way things are built. Also, 198 Australians in their last year of school highly agreed that ICT could be used for teaching (M=5.30, SD=0.73) and learning (M=5.25, SD=0.83). However, they were less sure about how to use ICT to teach (M=4.16, SD=0.91) and help students use ICT (M=3.59, SD=0.93). What this means is that beliefs and trust don't match up, which is straight proof of RQ1. PK/TPK goes up every year while TK stays the same in longitudinal TPACK (n=255). Students may not be able to do as well on TPACK even if they have a lot of access to gadgets (direct proof for RQ1). More poll results: 78% said ICT is essential, 61% said not enough training, and 22% said they were "confident in ICT for assessment. Overall, only 34.1% said they were very confident, and that number went up when teachers used ICT and students had practicum experience. This shows that PSTs value ICT but do not feel fully classroom-ready (direct evidence for RQ1). The data from the training method shows what makes people more ready, which is where RQ1 finds holes. ICT for managing lessons was negatively linked to role modelling by itself (−0.47, p=.03) in a program based on SQD strategies. Reflection, on the other hand, had a significantly positive effect on incorporating ICT into teaching contexts (^{2}=0.59, p=.027). Collaboration and real events were on the rise, but they weren't very important. This shows that tools can be turned into teachable practices through guided thought on true use (direct evidence for RQ2). SQD2 is a bigger change to the SQD framework. Its main tools are now modelling + exploration + hands-on practice + feedback + affective/digital-identity support. For this reason, planning needs to be done along with doing and debriefing to move TPK/TK (direct/indirect evidence for RQ2). Besides, project-based production can help students learn more advanced ICT skills and express themselves more effectively in the classroom. It can be used as an example of ICT work that is embedded and aligned with assessment in Australian ITE (indirect but method-relevant proof for RQ2). This shows how to close the gap between important and ready that was found in RQ1: Do not just show real, thoughtful, design-centered, feedback-rich events, include them.

Unreliable technology, limited access, language/learner factors, and low self-efficacy are all problems that teachers face in real life. These problems show up in analytical frameworks that show how PSTs adjust. Instead of just being exposed, these events show that directed problem-solving and self-reflection can help people feel more confident (direct support for RQ3). studs which mentioned in the Literature review found that the lack of OTL in TK/TPK schools is a structural issue: when technological OTL is scarce or taught as separate skills, PSTs start their placements with theory–practice. Comparing training modes (indirect triangulation for RQ3), these issues come up again. To put it simply, RQ2's methods need to be able to solve the same issues that slow down the growth of TK/TPK. These include not having enough OTL, classes that aren't useful in real life, and modelling with tools first.

Pre-service teachers in Australia think ICT is important, but they aren't quite ready to use it well in the classroom yet. Based on recent results from

Australia, the findings above show that confidence is highest for simple uses and lowest for student-centered tasks, opportunities to learn for techno-pedagogy are uneven, reflection tied to real lesson design works. The literature review comes to the same big picture, but with a different set of theories and policies. Knowing how to use tools is not enough, ICT needs to be a part of teaching, learning, and training over time. Consequently, this study agrees that there is a relevance–readiness gap and that we need to stop using tool courses and start incorporating practice-rich learning into the curriculum.

This study also agrees on several other points. First, having access to devices or being familiar with basic tools does not ensure transfer to the classroom. What counts is how PSTs learn to use ICT to teach (planning lessons, attempting them, receiving feedback, and thinking about them). Second, lack of trust in complicated, student-centered ICT work is due to systemic constraints like uneven inclusion in ITE, few chances for advanced integration, and variable modelling quality. Third, steps that can be taken to find solutions, which can be pictured as a cycle: model → hands-on discovery → instructional design → real-life use (micro-teaching or placement) → feedback → reflection → rethink.

However, there are some differences about literature review and findings. This is because of three main things. (1) Looking at modelling through different eyes. The results file looks at a specific case and shows that modelling alone (without doing, getting feedback, and reflecting) can be bad for using ICT to run a classroom. The review sees modelling as generally helpful because it doesn't tell the difference between strong and weak methods. In short, modelling has different effects depending on how it is used. (2) Different time and area. It's a short but detailed report on new research from Australia that looks at OTL, TPACK sub-domains, and what changed results. The review looks at a lot of different countries and years of work, including some older pieces of work and topics other than the basics of PST training. Because of this, it is better on why ICT should be used, but weaker on how to change the current Australian cohorts. (3) Different strengths of the information. The finding is based on training effects that can be measured, such as how thought leads to better use of ICT and how modeling-only leads to worse management outcomes. The review uses a mix of low-quality and high-quality sources and sometimes points out missing references. Because of this, its claims are more general and not as specific to anyone training plan.

Overall, this study leads to the same result. The literature review gives the idea and policy reasoning behind why it is necessary to do more than just use tools and develop techno-pedagogical skills across the degree. The results give the how to do it right now in Australia: make sure students have ongoing chances to learn TK/TPK and use SQD2-style loops of model → do → feedback → reflect → redesign in their classes and jobs. When put together, it is shows that schools should switch from putting ICT units at the beginning to degree-long, assessment-aligned, real cycles. This way, what PSTs think is important will become what they can do in class.

6 Conclusions

This review shows that most Australian pre-service teachers know how important ICT is for teaching, but they aren't always ready to use it effectively in the classroom. Their confidence is highest for simple/administrative tasks and lowest for more complex, student-centered ones. This is mostly because they don't have enough chances to learn technology and techno-pedagogy. There is evidence that the best training is not just one activity, but a combination of several. These include modelling along with hands-on practice, authentic tasks (microteaching/placements), feedback, and guided reflection. Reflection has the most positive effects, while modelling alone may not be enough to improve management skills. Some of the biggest problems are unstable access to technology, a lack of mentor support, time and task constraints, and low self-efficacy in some groups. These issues explain why the same training often has different outcomes in real life. To close the gap between relevance and readiness, ITE programs should switch from one-time "tool" courses to cycles that are built into the curriculum and include lots of practice (model → do → feedback → think → redesign). They should also make sure that TK/TPK students have structured chances to learn and improve guidance and infrastructure. In the future, these combined methods should be tested in a range of placing settings in Australia.

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